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RESPONSES OF BREEDING GOLDEN EAGLES TO RELOCATION

ROBERT L. PHILLIPS, *U.S. Department of Agriculture, Denver Wildlife Research Center, P.O. Box 25266, Denver, CO 80225*

JOHN L. CUMMINGS, *U.S. Department of Agriculture, Denver Wildlife Research Center, P.O. Box 25266, Denver, CO 80225*

JOHN D. BERRY, *Kiewit Mining Group, Inc., P.O. Box 3049, Sheridan, WY 82801*

Most studies of golden eagle (*Aquila chrysaetos*) predation on domestic livestock have been directed toward migratory eagles rather than territorial residents (O'Gara 1978). Relocations of problem migratory eagles had little demonstrated effect on depredation rates (Matchett and O'Gara 1987). A recent eagle-damage survey (Phillips and Blom 1988) suggested that, in many cases, resident golden eagles are responsible for chronic losses of young domestic lambs (*Ovis aries*), particularly in parts of Colorado, Wyoming, Montana, and Utah where relatively dense breeding eagle populations overlap with lambing areas (Boeker 1974). The feasibility of relocating depredating resident breeding eagles as a potential management tool for resolving eagle–livestock conflicts has not been investigated. Eagle management procedures that address resident eagles are needed to supplement those documented for migratory birds. The objectives of our study were (1) to evaluate the feasibility

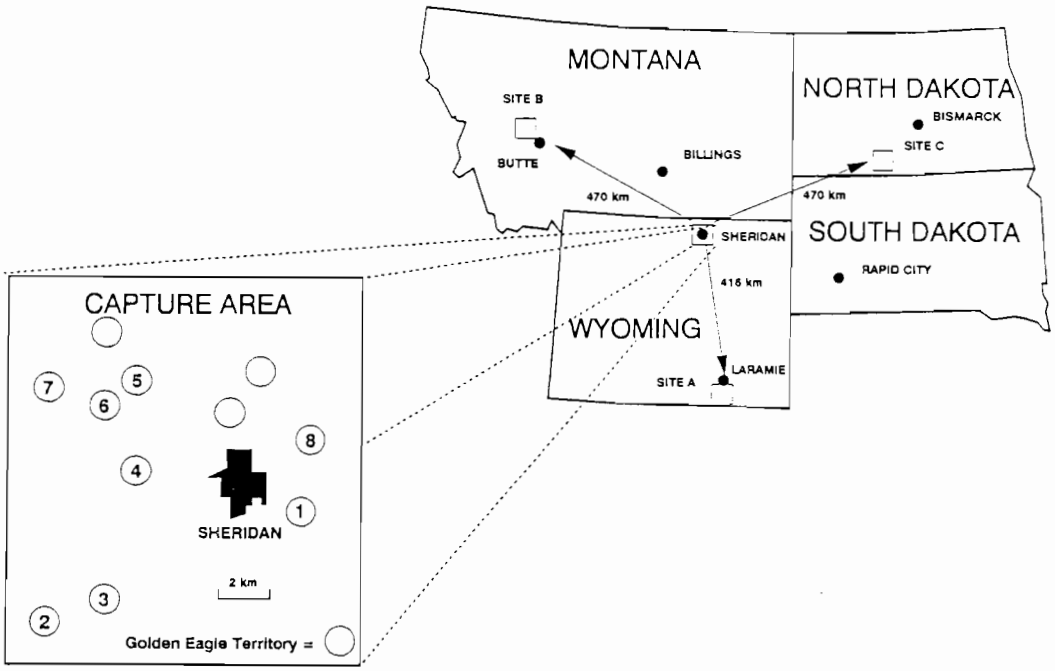

Fig. 1. Location of golden eagle capture area and relocation sites.

of relocating resident eagles, and (2) to determine the impact of this action on the local eagle population.

STUDY AREA AND METHODS

The study area was located in north-central Sheridan County, Wyoming (Fig. 1). This area is characterized by rolling hills and benches covered with sagebrush (*Artemisia tridentata*)/grassland (*Agropyron* spp.) and is used primarily for cattle grazing. Large cottonwood (*Populus deltoides*) trees located along the drainages are used as nesting sites by golden eagles. Thirty nesting pairs on and adjacent to the study area had been monitored for several years to obtain data on territory occupancy and reproductive performance (Phillips et al. 1990). Eagles used in our study did not have a history of preying on domestic livestock and were only considered as models for evaluating the effects of relocation. We assumed there were no behavioral differences between depredating and nondepredating eagles that would affect our assessment of relocation feasibility or population impact.

Field work was conducted from January 1988 to July 1990. Prior to capturing birds, pairs of breeding eagles were identified as potential "study pairs." Their territories were monitored from the ground and air to confirm the presence of both adults. Eagles were captured with padded No. 3 steel traps, a cannon net, or a net gun fired from a helicopter (O'Gara and Getz 1986). Captured eagles were sexed, banded, marked with colored patagial tags, and instrumented with tail-mounted radio transmitters. Eagles were transported and released at different locations following each capture period: in February and March 1988 at Site A, 416 km south of the capture area; in January 1989 at Site B, 470 km northwest of the capture area; and in December 1989 at Site C, 470 km northeast of the capture area (Fig. 1). Following the capture and relocation of birds, territories were monitored at 7–14 day intervals to determine if and when relocated birds returned to their territories and to document mate replacement. For 5 relocations we determined the actual date of a bird's return; for 9 relocations we report the time interval between the date the bird was known to be absent from its territory and the date it was first observed back (Table 1).

RESULTS AND DISCUSSION

Fourteen adult golden eagles (6 males and 8 females) were captured during the study. Two males were recaptured and relocated on

Table 1. Relocation dates, distance and directions of relocations, time to return and earliest date of return to territory, and fate following relocation for 14 golden eagles captured and relocated from Sheridan County, Wyoming, 1988–1989.

Territory No.	Sex	Date of relocation	Distance (km) and direction of relocation	No. days to return to territory	Earliest date confirmed back on territory	Fate following relocation
1	M	5 Feb 1988	416 S	11–31	9 Mar 1988	Regained territory
2	F	13 Feb 1988	416 S	105	30 May 1988	Regained territory
3	M[a]	15 Mar 1988	416 S	16–34	19 Apr 1988	Regained territory
		29 Jan 1989	470 NW	53–74	14 Apr 1989	Displaced from territory
	F	15 Dec 1989	470 NE	109–124	20 Apr 1990	Regained territory
4[b]	M[a]	15 Mar 1988	416 S	35	20 Apr 1988	Regained territory
		15 Dec 1989	470 NE	76–83	8 Mar 1990	Regained territory
	F	29 Jan 1989	470 NW	53–73	13 Apr 1990	Displaced from territory
	F	15 Dec 1989	470 NE	109	4 Apr 1990	Found dead below nest tree
5	F[c]	15 Mar 1988	416 S			Unknown
	F[d]	29 Jan 1989	470 NW	162–316	11 Dec 1989	Regained territory[e]
6[b]	M	15 Mar 1988	416 S	34	19 Apr 1988	Regained territory[e]
	F	15 Mar 1988	416 S	57	11 May 1988	Regained territory
	M[c,d]	29 Jan 1989	470 NW			Unknown
7	F	29 Jan 1989	470 NW	162–316	11 Dec 1989	Regained territory[f]
8	M	29 Jan 1989	470 NW	53–73	13 Apr 1989	Found dead below nest tree

[a] Relocated on 2 separate occasions.
[b] Both members of the pair were relocated the same day.
[c] No follow-up observations were made on these eagles following relocation.
[d] Replacement member of the pair for the individual relocated the previous year.
[e] Displaced from territory in 1988 breeding season but regained territory in 1989.
[f] Regained territory in 1990 breeding season.

2 separate occasions (21 and 23 months following original capture), making a total of 16 individual relocations. The male and female from 2 pairs (No's. 4 and 5) were relocated together on the same day, while all other eagles were released alone (Table 1).

Twelve of 14 relocated eagles returned to the vicinity of their former territories after being absent for a median time interval between 53 and 73 days (range = 11–31 days for the shortest interval to 162–316 days for the longest interval). Two eagles that were relocated in different directions on 2 separate occasions returned to their territories following each relocation. Males returned to their territories faster than did females (Wilcoxon rank sum test, $P \leq 0.02$). Males were located near their territories within 83 days following relocation, while 5 of 7 females took more than 105 days to return. Eagles relocated to the south returned faster (11–105 days) than those relocated in a northwest or northeast direction (53–>162 days), but these observations were not appropriate for statistical testing. Many factors such as weather and the timing of the relocation in relation to the nesting season most likely contributed to the differences in the return times. These results are similar to those reported by Boshoff and Vernon (1988), who relocated black eagles (*Aquila verreauxii*), crowned eagles (*Stephanoaetus coronatus*), and martial eagles (*Polemaetus bellicosus*) in South Africa. However, the distances our golden eagles were relocated were much greater than those reported for other species.

Mate replacement and reoccupancy of vacant territories by golden eagles can occur rapidly following the death of an individual from a mated pair (Phillips et al. 1984). Following our removal of eagles, all territories were quickly reoccupied by new mates or pairs that originated from a nonbreeding, nonterritorial subpopulation. Replacement times for individual mates ranged from 1 to 8 days ($\bar{x} = 2.6$,

SE = 0.9). In 1 case where we removed and relocated a pair, a new pair was seen in the territory 14 days later.

When relocated eagles attempted to reoccupy their former territories, they were challenged by "replacement eagles." In 7 of 16 relocations, birds reoccupied their former territories during the same breeding season while 2 others were observed on their territories the following nesting season. We observed 3 instances where relocated eagles were displaced from their former territory following their return from a relocation site. Two of these eagles (1 male and 1 female) remained on the periphery of their former territory, but did not reestablish a pair bond with their former mates. Another male eagle was displaced during the breeding season when it returned to its territory, but the following year was seen at the nest site with its former mate. Two relocated eagles died shortly after returning to their territories. Available field evidence suggested that their deaths resulted from fighting with replacement eagles near the nest trees. The fate of the 2 remaining birds was unknown as they were never observed following relocation.

The removal and relocation of adult eagles from our study area appears to have had minimal impact on the local breeding population or the nesting success of individual territories. An abundant supply of nonbreeders or nonterritorial birds was available to fill territorial vacancies. Nesting success for the 8 manipulated territories monitored in this study averaged 67% (1988–1990) as compared to the 11-year average of 54% for the local eagle population (Phillips et al. 1990).

The eagles we observed readily formed new pairs following the removal of a mate. In some instances, relocated birds were unable to regain their territorial status following return to their territory. These observations suggest that long-term pair bonding in golden eagles may not be as strong as indicated in the literature (Bent 1937, Brown 1976). Competition for available breeding territories in areas with an abundant supply of sexually mature eagles may result in different eagles being present in traditional territories on an annual basis. This hypothesis needs further testing.

CONCLUSIONS

Our observations of 14 relocated resident golden eagles showed a well-developed homing instinct for this species, with 12 of 14 individuals returning to their former territories. All golden eagles were absent from their territories at least 11 days with some being gone for more than 162 days. The range of time periods that relocated eagles remained absent from their territories would allow most young lambs to grow large enough to be less attractive prey. We assumed that depredation problems from replacement birds would be minimal because most eagles do not prey on livestock. Because most relocated birds reestablished their territories, it appears that relocation of breeding adult eagles offers, at best, only a short-term solution to the problem of eagle predation on livestock.

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